Study on High Dielectric Constant Cermaics. (VII) : Electrical Resistance of BaTiO Ceramics

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Pc and Pd increase with field intensity, and there appears a tendency of saturation at about 7,000 V/cm. The values of Pc and Pd at 20,000 V/cm are about 9 and 4.5 μ Coulomb/cm^2 recpectively, and it is shown that there rimains about half of Pc after the field is removed. A similar result is obtained from the measurement of Pr.

The temperature characteristics of Pc, Pd and Pr, show that Pc and Pd take same values above Curie point, and Pr becomes zero near the same temperature.

The relations between the values of Pr and the time of exposure to field from 10^{-2} to 10^3 sec., shows that Pr is very much influenced by time of exposure when field is comparatively small, but not so much at large field.

Coercive field was measured in the same manner, and it was found that it takes the value of about 6,000 V/cm at large field intensity.

16. Study on High Dielectric Constant Cermaics. (VII)

Electrical Resistance of $BaTiO_3$ Ceramics.

Kiyoshi Abe and *Tetsuro Tanaka.*

As $BaTiO_3$ changes its crystal structure at Curie point, it is expected that there appears an abnormal change on electrical resistance of $BaTiO_3$ ceramics near this temperature. Below Curie point, the crystal has domain structure and suffer remarkable influence from applied voltage, so the influence of voltage on resistivity is also expected. Eperiments were carried out to confirm these expectations. Special cares were taken to avoid experimental errors due to the ferroelectric properties of such materials.

The experimental result obviously shows the abnormal change of resistivity near the Curie point, and log R versus $1/T$ curve becoms two straight lines kink seperated at this temperature. Values of ΔE and R_0, calculated from the next formula, are summarized on Table 1.

$$R=R_0 e^{\frac{\Delta E}{KT}}$$

Table 1.

Applied Voltage V/cm	ΔE_h. eV	ΔE_l. eV	R_0h Ohm-cm	R_0l Ohm-cm
1750	1.06	0.76	4.4×10^{-4}	66.7
8330	1.14	0.78	3.2×10^{-5}	1.5
16670	1.22	0.95	1.7×10^{-6}	6.1×10^{-3}

In Table 1, ΔE_h, R_0h ahd ΔE_l, R_0l are that above and below Curie point respectively.

Above Curie point, resistivity decreases with increase of applied voltage, which seems to agree with the properties of ordinary dielectrics. Below Curie point, on

the other hand, another tendency occurs; at room temperature, resistivity increases with voltage increase. This phenomenon is explained by the facts that domains are lined up along the direction of the field in accordance with the field intensity, and the resistivity along the polarization axis is larger than that of another axis. It is also explained by the decrease of effective field in crystal due to the orientation of domains along the direction of the field.

17. On the Dielectric Properties of Starch. (II)

The Complex Dielectric Constant at High Frequency.

Naokazu Koizumi, Sozaburo Ono and Takashi Kuge.

The dielectric constant ε' and loss ε'' of the starch-liquid paraffin system at the frequencies from 3 MC to 30 MC were measured with the susceptance variation method at the temperature range from 10° to 55°C.

The samples were both α- and β-modifications of various starches (potato, waxy rice, lily bulb and amylose etc.), and were preparen in the same way as in the preceding report. (This Bulletin, **20** 46 (1950))

The maximum value of loss ε''_{MAX} appeared at a given temperature or frequency corresponding to moisture content, and the increase of moisture shifted ε''_{MAX} to lower temperature at a given frequency and to higher frevuency at a given temperature.

Moreover the dispersion curve for zero moisture percentage was very similar to the one for lower percentage. Any remarkable difference was neither found among the sorts of starch, nor between the both modifications.

According to the theory of absolute reaction rates the free energy $\Delta F^{\ddagger}$, heat $\Delta H^{\ddagger}$ and entropy $\Delta S^{\ddagger}$ of activation in the dielectric relaxation process were evaluated from the temperature dependence of relaxation time, and approximate values of them are as follow.

Moisture content (in%)	Relaxation time $\bar{\tau}$ at 20°C (in second)
0	1.10^{-7}
10	1.10^{-8}
16—17	1.10^{-9}

$\Delta F^{\ddagger}$ 6~8 Kcal/mol
$\Delta H^{\ddagger}$ 7~11 Kcal/mol
$\Delta S^{\ddagger}$ 5~10 e. u.

Because the number of H_2O molecule loosely bound with starch becomes more in case of higher moisture percentage, it is reasonable that the more the moisture content, the smaller the value of mean reluxation time $\bar{\tau}$, and that the larger values of $\Delta F^{\ddagger}$ and $\Delta H^{\ddagger}$ correspond to lower moisture content and the smaller values to higher content.

From the above results it may be considered that the dispersion of dielectric constant in the starch-liquid paraffin system at ultra high frequency and high frequency is due to the rotation of dipole of hydroxyl group in water and starch molecules.